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Notes:
1. Untranslatable words are replaced with asterisks (****).
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CLAIM + DETAILED DESCRIPTION

[Claim(s)]

[Claim 1] In the production method by the laser evaporating method of a monoatomic layer carbon nanotube which irradiates laser at a carbon rod The production method of the monoatomic layer carbon nanotube characterized by controlling the path of this nanotube by changing this ambient temperature based on the correlation of the ambient temperature of the carbon rod of a non-glaring part, and the path of a carbon nanotube.

[Claim 2] In the production method by the laser evaporating method of a monoatomic layer carbon nanotube which irradiates laser at a carbon rod The production method of the monoatomic layer carbon nanotube characterized by controlling the path of this nanotube by changing this catalyst metal kind based on the correlation of the path of the catalyst metal kind in a carbon rod, and a carbon nanotube.

[Claim 3] The monoatomic layer carbon nanotube obtained with the production method of the description by Claim 1 or either of 2.

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the production method of a carbon nanotube. The production method of this invention is changing the metal catalyst kind in ambient temperature or a carbon rod. The point that the diameter of a fiber of the carbon nanotube of a monoatomic layer is controllable is the greatest feature, and it is suitably used in the electronics field etc. as a carbon nanotube of the monoatomic layer by which the diameter of a fiber was controlled.

[0002]

[Description of the Prior Art] The carbon nanotube is expected as a new material with which it

will be discovered in 1991 (Nature, 354, 56 (1991)), and it is expected that potential application of versatility, such as ******, a one-dimensional wire, and a catalyst, is. The cylindrical size of the usual carbon nanotube with which the above cylindrical black lead layer was partly formed in concentric circular was not constant, and big variation was in an electrical property or the chemistry characteristic. Then, the production method of the monoatomic layer carbon nanotube by which the form of the tube was controlled by the monolayer is proposed by JP,H7-197325,A. Specifically in the production method of the carbon nanotube by an arc discharge method, the monoatomic layer carbon nanotube is manufactured by using carbon for one side of an electric discharge electrode, using the mixture of metal (transition metals, such as Fe, Co, and nickel) and carbon for the electrode of another side, and using hydrocarbon for material gas.

[0003] These days comes and the group of Smalley and others is manufacturing the monoatomic layer carbon nanotube by quantity **** not by an arc discharge method but by the laser evaporating method. The carbon (1.2 wt(s)each %) rod into which nickel/Co=1/1 went as a catalyst metal is specifically used, and it is the double [in an electric furnace] laser evaporating method. The rope-like monoatomic layer carbon nanotube has been obtained by very high **** (A. Thess etal., Science 273(1996) 483). However, even if **** of the monoatomic layer carbon nanotube improved, it was not able to control the path of the carbon nanotube of a monoatomic layer.

[0004]

[Problem to be solved by the invention] Then, this invention person sets to the production method by the laser evaporating method of a carbon nanotube, as a result of inquiring wholeheartedly that the above-mentioned technical problem should be solved. By the ambient temperature or the catalyst metal kind of a carbon rod of a non-glaring part finding out having the path and correlation of a monoatomic layer carbon nanotube, and changing ambient temperature or a catalyst metal kind based on this relation It found out that the path of a monoatomic layer carbon nanotube was controllable, and this invention was reached.

[0005]

[Means for solving problem] Namely, this invention is set to the production method by the laser evaporating method of the monoatomic layer carbon nanotube which irradiates laser at a carbon rod. By changing this ambient temperature based on the correlation of the ambient temperature of the carbon rod of a non-glaring part, and the path of a carbon nanotube The production method of the monoatomic layer carbon nanotube characterized by controlling the path of this nanotube, Or by changing this catalyst metal kind based on the correlation of the path of the catalyst metal kind in a carbon rod, and a carbon nanotube It consists in the monoatomic layer carbon nanotube manufactured by the production method of the monoatomic layer carbon nanotube characterized by controlling the path of this nanotube, and

the method of one of the above.

[0006] This invention is explained in detail hereafter. The greatest feature of this invention is at the point of controlling the diameter of a fiber of a monoatomic layer carbon nanotube, in the production method by the laser evaporating method of a carbon nanotube by changing the catalyst metal kind in the ambient temperature of the carbon rod of a non-glaring part, or a carbon rod.

[0007] [lower / the ambient temperature of the carbon rod of a non-glaring part] in the production method by the laser evaporating method of a carbon nanotube specifically Or the diameter of a fiber of a monoatomic layer carbon nanotube can be made small by changing the catalyst metal in a carbon rod into Rh/Pd from nickel/Co. The production method of this invention is the combination of the two above-mentioned parameters, and is an epoch-making production method which can control freely the diameter of a fiber of a monoatomic layer carbon nanotube.

[0008] The schematic view of the manufacture equipment of this invention is shown in drawing 1 . this equipment -- 1:electric furnace, 2:carbon rod, and 3:Nd-YAG laser 532nm, 4:Ar gas induction, 5:vacuum pump exhaust air part, and 6: -- it consists of a silica tube, 7:vacuum chamber, a 8:pressure gauge, a 9:valve, and a 10:lens. Although Ar is effective as inactive gas used by this invention, gas, such as helium, Ne, Xe, Kr, and Rn, can be used besides these gas. 100 - 2500Torr of pressure is desirable. Especially in Ar, 200 - 600Torr is the optimal, and, in the case of low-molecular quantity gas, such as helium, **** is maintainable by making pressure high.

[0009] Although the laser in particular used by this invention does not limit, Nd-YAG, CO2, an excimer laser, etc. are used suitably that a wavelength should just be the laser of 11 micrometers - the 250nm range. Energy density is 100-2000mmJ/cm2. It is suitable. Although continuation may also be unable to manufacture laser radiation, it is more desirable for the point of **** to carry out a pulse oscillation. This is presumed because laser is glared and destroyed by the nanotube under growth when continuation irradiation is carried out.

[0010] The carbon rod used by this invention consists of carbon and catalyst metal. A carbon rod can be obtained by being able to manufacture by a usual state method, for example, calcinating commercial carbon powder and catalyst metal, such as graphite powder, with a binder like graphite cement or phenol resin.

[0011] Although nickel, Co, Rh, and Pd are desirable and do not limit in particular as a catalyst metal in a carbon rod, what mixed Rh:Pd for nickel and Co, and the thing which added nickel, Co, and Rh independently are used suitably. When using it, mixing catalyst metal, it does not limit especially as a mixed ratio, but from a viewpoint of ****, 1:1 is desirable. In order to, obtain the desired diameter of a tube, of course, making it rates other than 1:1 is considered enough. In addition, since a monoatomic layer carbon nanotube is not generated, it is [a Pd

independent] desirable [a carbon nanotube] to use it, mixing Rh and a suitable rate. 0.05 - 2.0atomic% of the amount of addition of catalyst metal is respectively desirable.

[0012] Preferably, ambient temperature is 600-1500 degrees C, and is 100-1300 degrees C still more preferably. Above 600 degrees C or less and 1500 degrees C, **** of a carbon nanotube falls extremely, and it is not realistic. The diameter of a fiber of a monoatomic layer carbon nanotube becomes small, so that the ambient temperature of the carbon rod of a non-glaring part is low, when the same metal catalyst is used. It is because temperature will not reach a balance under the influence of laser light if it is the irradiation part which is considered as a non-glaring part here. Moreover, when it was made to generate at the same temperature and the catalyst metal kind in a carbon rod was changed with nickel, nickel/Co, Co, Rh, and Rh/Pd, it found out that the diameter of a fiber became small at the order.

[0013] Therefore, the diameter of a fiber of a monoatomic layer carbon nanotube can be made small by making ambient temperature low, using a big catalyst metal of an atomic weight. That is, the diameter of a tube of a monoatomic layer carbon nanotube is controllable by changing a catalyst metal kind and ambient temperature. The production method of this invention is the combination of the two above-mentioned parameters, and it is the epoch-making production method which can control freely the diameter of a fiber of a monoatomic layer carbon nanotube. The monoatomic layer carbon nanotube by which the diameter of a fiber obtained with the production method of this invention was controlled is suitably used in the electronics field etc.

[0014]

[Working example] Hereafter, although a work example explains this invention still in detail, this invention is not limited by the following work example, unless the summary is exceeded. (Work example 1) The schematic view of equipment is shown in drawing 1 . Graphite powder (Product made from NIRAKO) and the metal powder (Product made from NIRAKO) of nickel/Co were mixed, and it hardened into graphite cement (Product made from NIRAKO), it heat-treated at 1200 degrees C by Ar atmosphere, and the carbon rod was produced. the inside of the silica tube set in the electric furnace -- nickel/Co=1:1 -- 0.6 atomic(s)each % -- the added carbon rod (6mm phix30mm) was placed, and it was considered as Ar atmosphere, and pressure was set to 500Torr and ambient temperature was 1200 degrees C. The Nd-YAG laser (made by Spectra-Physics) of wavelength [of 532nm] and energy density 300mj/cm2 and 10Hz pulse light was irradiated by spot size 6mmphi at this carbon rod. The output adhering to **** was collected and Raman spectrometry was carried out, using argon-ion-laser 488nm and 20mW as TEM observation and a source of excitation light. Although a TEM photograph is shown in drawing 3 , it turns out that it is a monoatomic layer carbon nanotube. The Raman spectrum is shown in drawing 2 . About the path of a tube, it is Science. vol.275 1997 It turned out that it estimates with the peak position by the Raman scattering

spectroscopy of p187 -191 description, and the relation of the diameter of a tube, and distribution of the diameter of a tube has a peak near 11A.

[0015] (Work example 2) When experimented like the work example 1 except ambient temperature having been 1000 degrees C, in distribution of the diameter of a tube, it turned out that near 10A is a peak.

(Work example 3) When experimented like the work example 1 except ambient temperature having been 1300 degrees C, in distribution of the diameter of a tube, it turned out that near 13.5A is a peak.

[0016] (Work example 4) setting catalyst metal to Rh/Pd=1:1 -- 1.2 atomic(s)each % -- when it experimented like the work example 1 using the added carbon rod except ambient temperature having been 1000 degrees C, as for distribution of the diameter of a tube, it turned out that near 7.8A is a peak.

(Work example 5) When experimented like the work example 4 except ambient temperature having been 1200 degrees C, in distribution of the diameter of a tube, it turned out that near 9.0A is a peak.

[0017] (Work example 6) When experimented like the work example 4 except ambient temperature having been 1300 degrees C, in distribution of the diameter of a tube, it turned out that near 11.0A is a peak.

(Work example 7) setting catalyst metal to Rh -- 0.6atomic% -- when it experimented like the work example 1 using the added carbon rod except ambient temperature having been 1200 degrees C, as for distribution of the diameter of a tube, it turned out that near 10.5A is a peak.

[0018]

[Effect of the Invention] The monoatomic layer carbon nanotube by which the diameter of a fiber obtained with the production method of this invention which has the above-mentioned feature was controlled is suitably used in the electronics field etc., and offers great industrial profits.

[Translation done.]